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Study on 20 and 50 Gbps Soliton Transmission in Conventional Single Mode Fiber (SMF)

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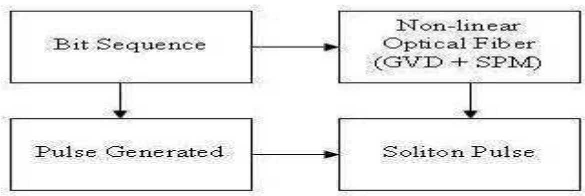
Abstract - In this paper we study the soliton transmission in single mode fiber for the 20 and 50 Gbps. Each bitrate of the system confines its own signal power and induce the nonlinearity effect. We also measure the chirping effect of the pulse before and after transmitting along the fiber for the different levels of input power and dispersion effect on soliton pulse under the GVD and second order non linear effect pulse propagation. The order of soliton is calculated with respect to periodical distribution along the fibre, here the fundamental period of soliton is analyzed. As like that other higher order soliton with account of dispersion length and non linear length can be related as in case of fundamental solitons. The soliton transmission system can be designed using photonic crystal fibre as like in single mode fibres with this same system modeling.

Keywords – Soliton pulse, GVD, bitrate I.

INTRODUCTION

In a long haul communication link, single mode fiber is mostly preferred due to less impact of dispersion effect rather than the multimode fiber. In conventional single mode fiber, for the higher order bitrate data we require high level of powers in order of 100mw, due to the high intensity input pulse there is sum criteria of existing non linear effect like self phase modulation and four wave mixing, here we consider both the non linear effect (Kerr effect) and group velocity dispersion effect to produce a narrow width with high peak power intensity pulse is called as soliton [1]. Soliton is a kind of pulse which has a packet of energy to carry the information over long haul communication. When we managing the group velocity dispersion (anomalous dispersion regime), and self phase modulation (positive dispersion regime), we can create a soliton pulse [2,3]. The effect of soliton communication is desirable for long distance communication system with high data rate of the system [4,5].



In a optical communication system soliton pulse are narrow with high intensity optical pulse that retain their shape through the interaction of balancing pulse dispersion with the non linear properties of an optical fiber. The family of soliton pulse that do not change in shape called fundamental solution and there that undergo shape changes are called high order solitons [6,7].

When a narrow high intensity pulse propagating along the medium with anomalous GVD parameter which counteracts the chip produced by the Kerr effect [8]. GVD retards the low frequencies in the front of the pulse and influence the high frequencies at the back end of the pulse. The result is soliton pulse change neither its shape nor its spectrum as they traveling along the fiber.

II. SYSTEM MODELING

Two kind of bit rate is analyzed at 20 Gbps and 50 Gbps. Both the bit rate of the system has its own input signal power and same non linear index medium.

Consider the bit rate 20 Gbps, so the bit slot is 50ns from that the half power pulse with is calculated as 25 ps so T_{FWHM} is 25 ps. The soliton pulse have a relation for full width half maximum to the initial pulse width as

$$T_{FWHM} = 2\ln(1+\sqrt{2})\, T_o \approx 1.763\, T_o$$

The original pulse has time slot of T_o = 14.1803ps. The other terms for calculating to find the input signal power are dispersion length (L_D), dispersion coefficient (β_2), Non-linear length (L_{NL}) can be calculated as

$$L_D = \frac{T_0^2}{\beta_2} \tag{1}$$

$$L_{NL} = \frac{1}{\gamma P_0} \tag{2}$$

$$\gamma = \frac{n_2 \omega_0}{c A_{eff}} \tag{3}$$

Where is 20.1 PS^2/km, A_{eff} = 80 μm^2 , n_2 = 3 X 10^{-20} m^2/w

Using the above relation we can calculate the input power as 65.76 mw for 20 Gbps. In similar way for the 50Gbps system, the input power is calculated as 411.0144mw (initial pulse width of T_0 = 5.67).

For the soliton pulse the dispersion length is equal to the Non-linear length (L_D = L_{NL}) is called as fundamental soliton from

$$N^2 \geq \frac{L_D}{L_{NL}} \quad (4)$$

The soliton period is calculated as 15.714km from (4).

The parameter is also compared for 20 & 50 Gbps transmission system:

S.no.	Parameters	Calculated values		Units
		20 Gbps	50Gbps	
1.	T_{FWHM}	25	10	ps
2.	T_0	14.18	5.67	ps
3.	Power (P)	65.76	69.305	mW
4.	Non-linear Coefficient (γ)	1.52		$W^{-}Km^{-1}$
5.	Dispersion length (L_D)	10.0041	1.6006	Km
6.	Non-linear length (L_{NL})	10.0041	1.6006	Km

III. SIMULATION RESULTS AND ANALYSIS

The soliton pulse can be developed from the Non linear schrodinger equation (NLS) is given by

$$-j\frac{\partial u}{\partial z} = \frac{1}{2}\frac{\partial^2 u}{\partial t^2} + N^2|u|^2u - j\left(\alpha/2\right) \quad (5)$$

Here u (z, t) is the pulse envelope function, z is the propagation distance along the fiber, α is the coefficient of energy gain / unit length and N is an integer.

The fundamental soliton is given by,

U (z, t) = Sech (t) exp (jz/2)

Where Sech (t) is the hyperbolic secant function here the phase term does not make any effect on the pulse traveling in the system.

The following results have been analyzed for the 20 and 50 Gbps system

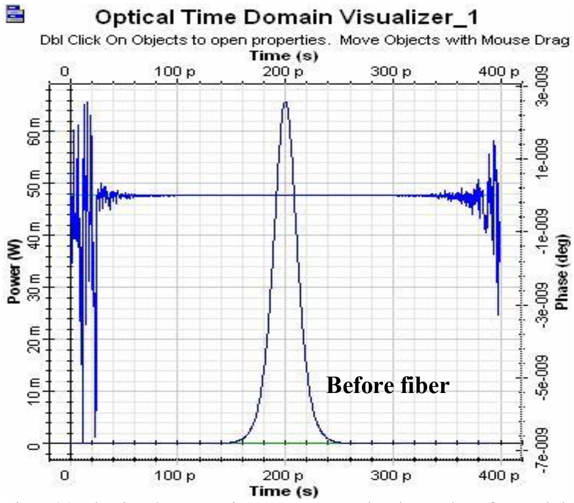


Fig 1.(a) Plotting between input power to the time taken for each bitrate

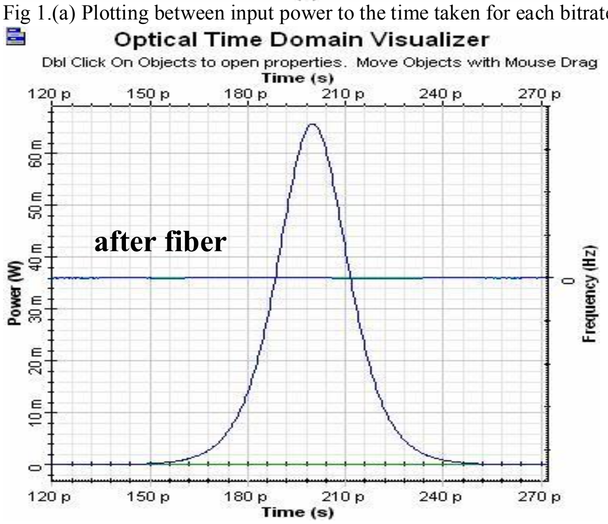


Fig 1.(b) Plotting between output power to the time taken for the input pulse with chirping effect

From Fig. 1(a) sech pulse generated for the given input sequence with power of 65.76 mw with chirping effect occur at 0 frequency. After propagating along the fiber, the signal is taken as Fig. 1(b) in which the signal power does not get attenuating due to the combined effect of GVD and self phase modulation is nothing but soliton effect and also the another term for defining the soliton pulse is chirping at 0 frequency. From both Fig.1(a) and Fig. 1(b) the input power has the same input power level at 65.76mw and chirping at 0 frequency.

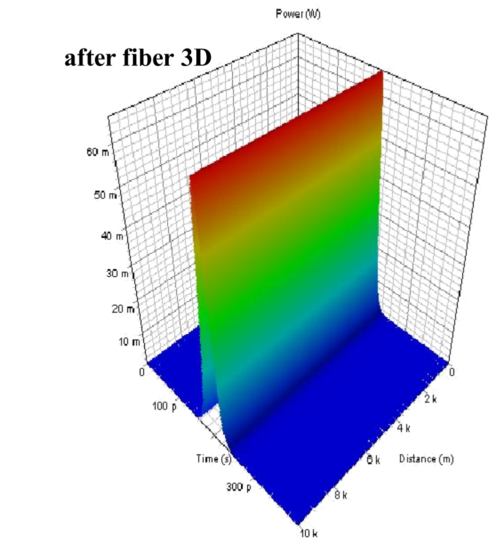


Fig. 1(c) Waveform shape in 3D plot

From this Fig. 1(c) show that 3D plot of output waveform for the 20 Gbps system with un shaping pulse for the input pulse. The dispersion length is 10km, the input power is 65.76mw as shown here.

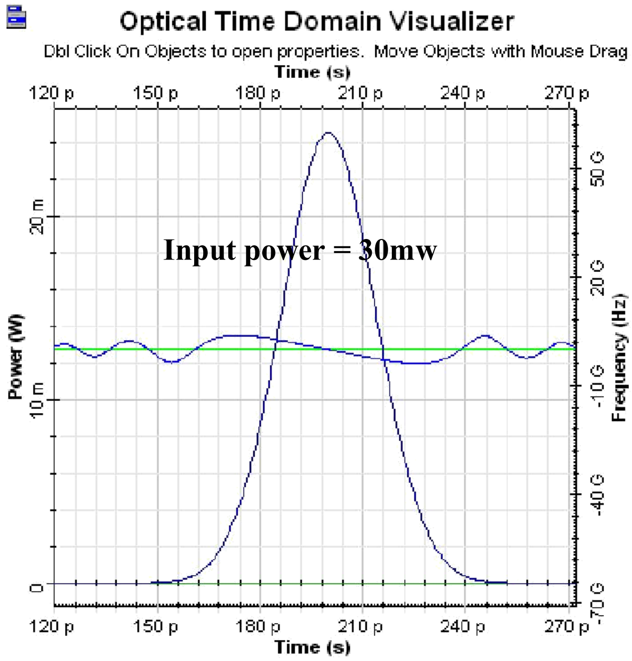


Fig. 2 (b) Chirping effect for the 30mw power

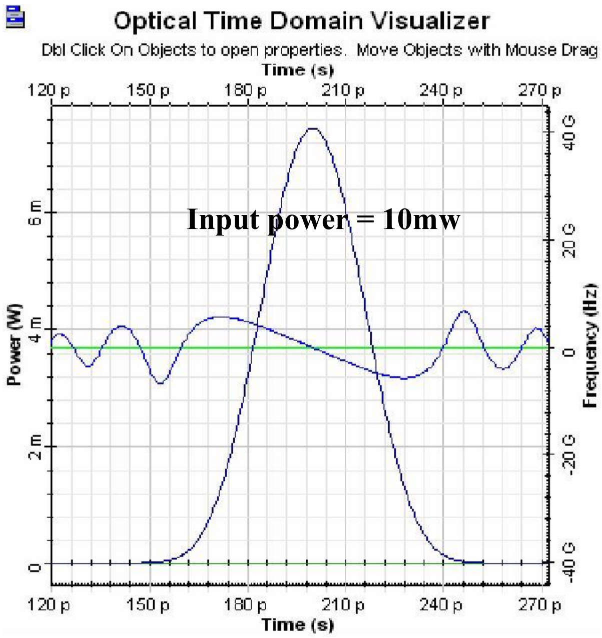


Fig. 2(a) Chirping effect for the 10mw power

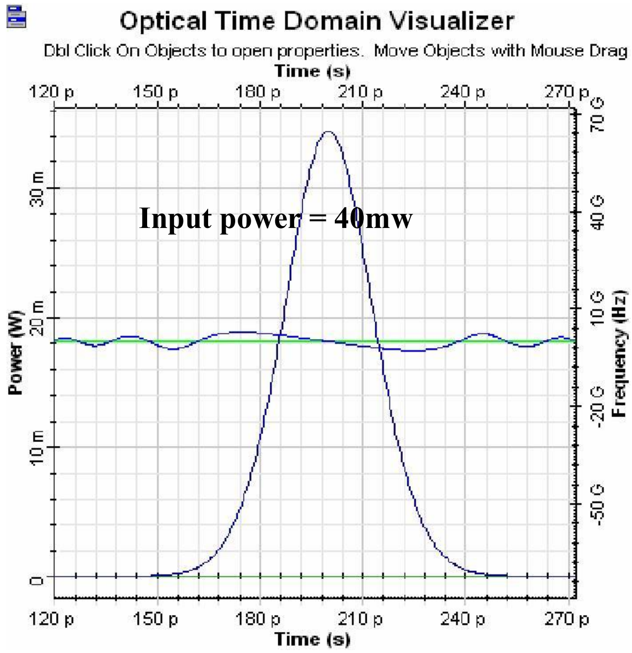


Fig. 2 (c) Chirping effect for the 40mw power

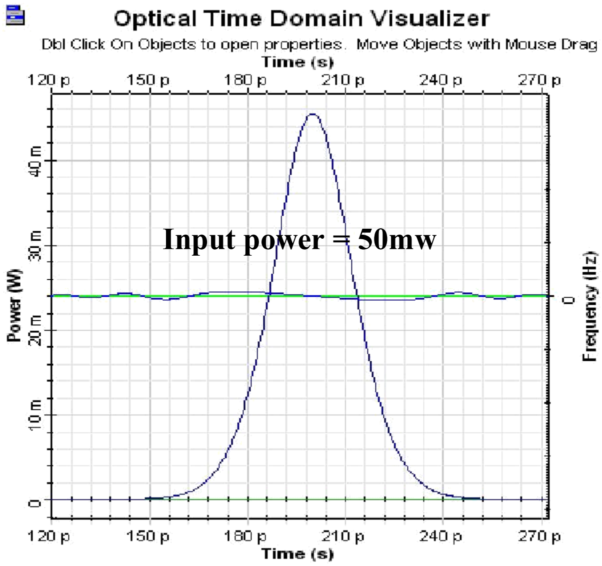


Fig. 2 (d) Chirping effect for the 50mw power

As shown in Fig. 2 (a), (b), (c) and (d) the chirping pulse is confined for the different levels of input power and chirping pulse nearly lies at 0 frequency with the input pulse as the power is increasing to the desire power level (65.76mw) from the figure we can see leading and trailing edge of the pulse is getting coherent with input sech pulse as the increasing power to us calculated desire power. We can clearly infer the matching of input pulse to the chirping pulse at 20 Gbps system.

In a similar way the graphical analysis of soliton propagation along the fiber for the 50 Gbps system is measured and plotted. Here the input power is 411.0144 mw.

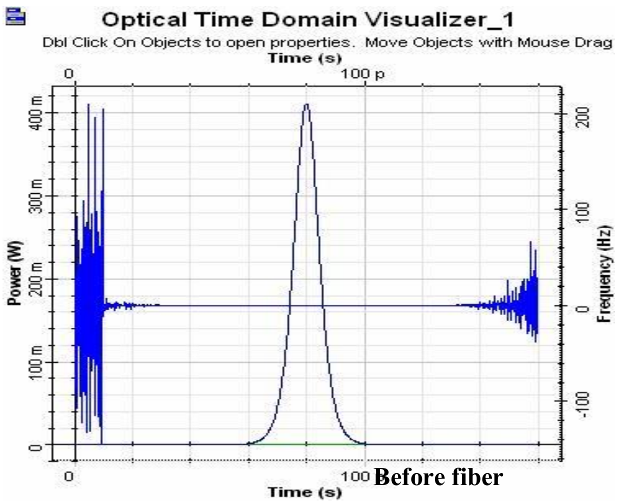


Fig 3 .(a) Plotting between input power to the time taken for each bitrate

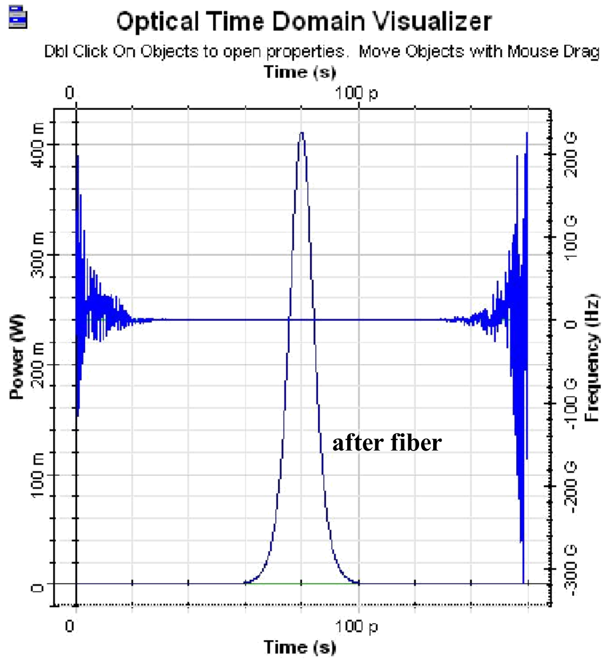


Fig 3.(b) Plotting between output power to the time taken for the input pulse with chirping effect

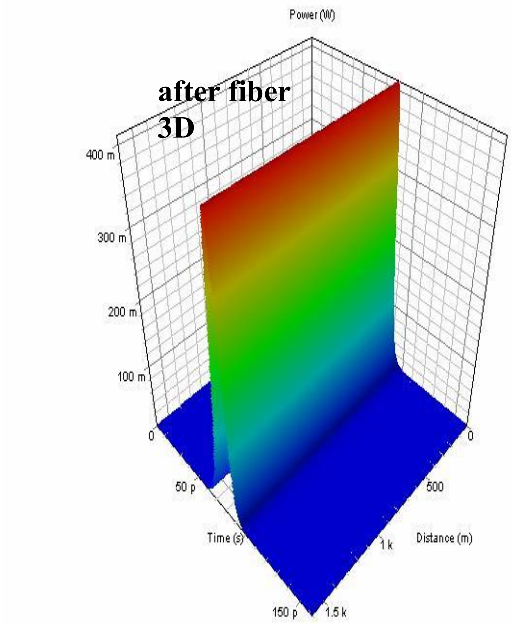


Fig. 3 (c) Waveform shape in 3D plot

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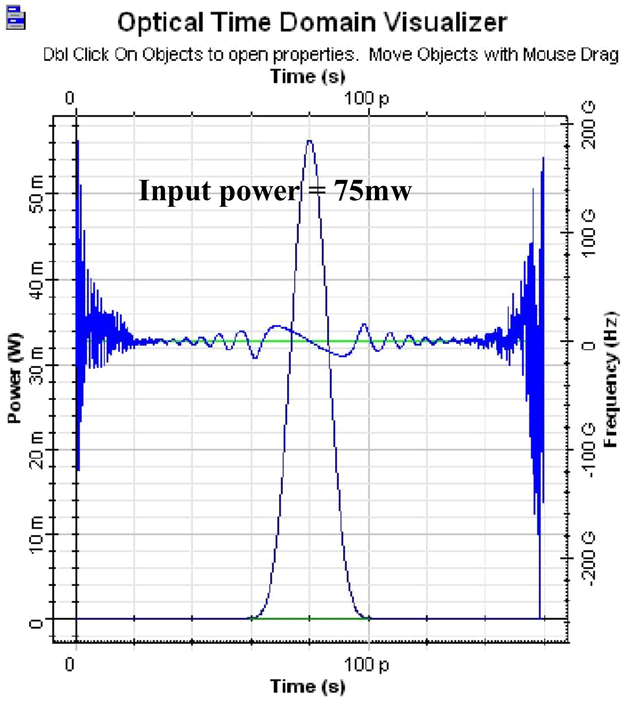

Fig. 4 (a) Chirping effect for the 75mw power

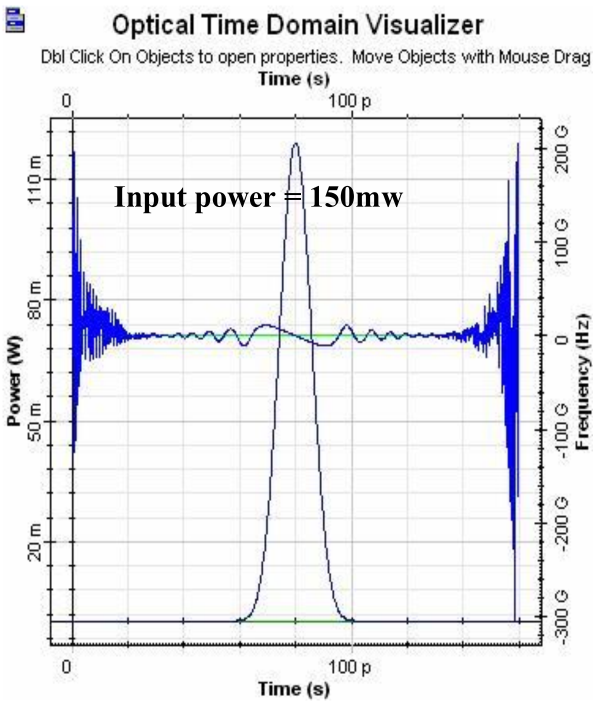

Fig. 4 (b) Chirping effect for the 150mw power

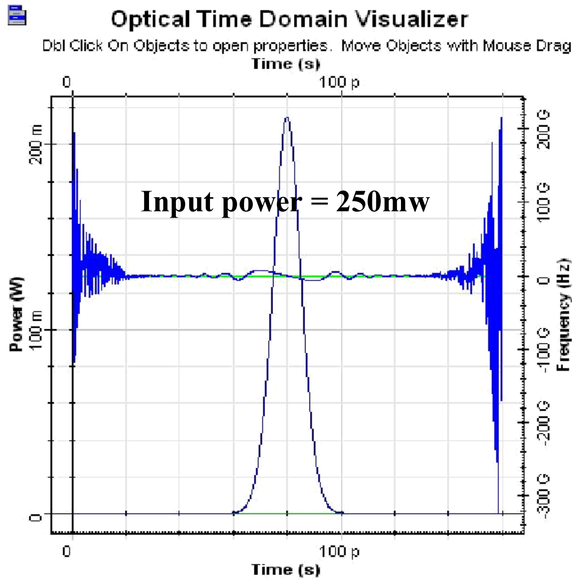

Fig. 4 (c) Chirping effect for the 250mw power

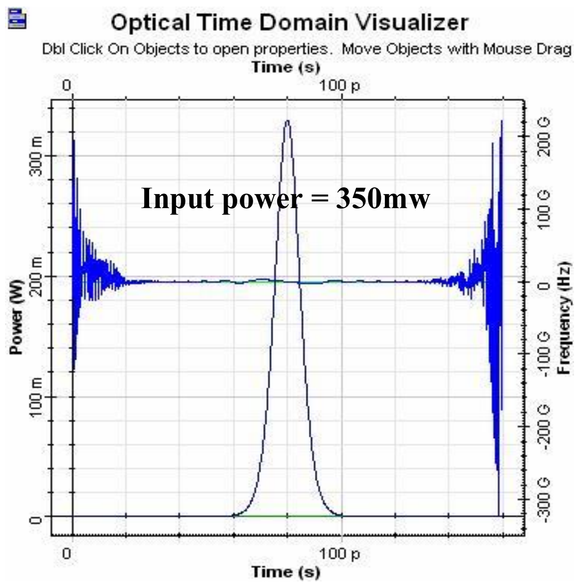

Fig. 4 (d) Chirping effect for the 250mw power

As shown in Fig. 4 (a), (b), (c) and (d) chirping pulse is adjusted to the 0 frequency line for the respective power levels and changing input power gives change in chirping pulse at leading and trailing edge.

Here we can also plot soliton pulse generation for the different kind of order (N) to the calculated input signal power using the formula of equation (4).

IV. CONCLUSION

We have analyzed the soliton pulse propagation along the fiber with different bitrate of the system here 20Gbps and 50Gbps and also studied the chirping effect on the input pulse as well as output pulse with variation at input signal power and measured the exact chirping balance on the pulse envelope at the optimized signal power as we calculated. In a same way we can design a soliton propagation system for the different data rate system in numerical as well as graphically.

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REFERENCES

1. J. Toulouse, "Optical nonlinearities in fibers: Review, recent examples, and systems applications", J.Lightwave Technol., vol.23, pp. 3625-3641, Nov.2005.
2. D. Gloge, E.A. J. Marcatili, D. Marcuse, and S.D. Personick, "Dispersion properties of fibers", in Optical Fiber Telecommunications, S.E. Miller and A.G. Chynoweth, eds., Academic, New York, 1979.
3. M. Kato, K. Kurokawa, and Y. Miyajima, "A new design for dispersion-shifted fiber with an effective core area larger than 100 μm ^{2} and good bending characteristics," 1998 OSA Tech. Digest – Opt. Fiber Comm. Conf (OFC 98), pp. 301-302, Feb.1998.
4. A.V. Belov, "Fiber design with effective area over 100 μm ^{2} for long-haul communication lines," J.Opt. Commun., Vol.22, no.2, pp. 64-66, 2001.
5. R. Ramaswami and K.N. Sivarajan, Optical Networks, Morgan Kaufmann, San Francisco, 2nd ed., 2002.
6. Shahidinejad, A., Soltanmohammadi, S., Amiri, I.S., Anwar, T., Solitonic Pulse Generation for Inter Satellite Optical Wireless Communication. Quantum Matter 2014; 3(2): 150-154.
7. Y. Lai and H.A. Haus, "Quantum theory of solitons in optical fibers. II. Exact solution", Physical Review, vol.40, pp. 854-866, July 1989.
8. H.A. Haus, "Optical fiber solitons: Their propertie s and uses," Proc. IEEE, Vol.81, pp-970-983, July 1993.
9. G.P. Agarwal, "Nonlinear Fiber Optics", 5 th edition, Academic press, 2013.